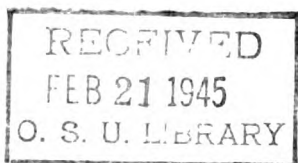


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INFORMATION CIRCULAR

SHAFT SINKING BY STRIPPING CHURN-DRILL HOLES



BY

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UNITED STATES DEPARTMENT OF THE INTERIOR - BUREAU OF MINES

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By W. A. Cole²

INTRODUCTION

As the mines get older and the active workings get farther and farther away from the original mine openings, it becomes increasingly difficult and expensive to ventilate most coal mines properly. At the same time, the avenues of escape for those employed underground have become so extended as often to make it impossible for them to make their way out of the mine in the event of a fire, mine explosion, or other emergency.

Where such conditions exist, the only satisfactory solution is to make new ventilation and emergency-escape openings near the active mine workings. At most mines this would necessitate sinking shafts, which is often slow and expensive.

The problem of relatively inexpensive as well as relatively expeditious shaft sinking under favorable conditions, which are not unusual in the Central States coal region, has been solved at one mine in southern Indiana.

This paper describes the method of sinking shafts by stripping small-diameter churn-drill holes as employed at the Ditney Hill mine of the Ingle Coal Corporation, Elberfeld, Warrick County, Ind.

ACKNOWLEDGMENT

The writer wishes to acknowledge the cooperation of the officials of the Ingle Coal Corporation, through W. D. Ingle, vice president, in furnishing the data used in this paper.

GENERAL DISCUSSION

Two vertical, 8-foot-diameter, steel-plate-lined mine shafts were sunk at this mine by stripping a 12-inch-diameter churn-drill hole in each, into which the muck was shoveled and dropped to the mine workings below; it was then loaded mechanically at the bottom of the churn-drill hole. This method was employed in sinking an air shaft 97 feet deep in 1940 and an emergency escape shaft to a depth of 147 feet in 1942. The air shaft is near the mine slope, and the escape shaft is approximately half a mile northeast of the slope.

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The formation at the Ditney Hill mine is a hard, gray shale or sandy shale overlying the coal. Surface soil and clay to a depth of 12 feet were encountered in both shafts. Water seepage did not amount to more than 300 gallons in 24 hours in either shaft.

CYCLE OF OPERATIONS

The procedure in the construction of the shafts was as follows:

1. A 12-inch-diameter churn-drill hole was first put down at the shaft site to a mine room or entry below. Care was taken in the drilling to keep the hole centered in the proposed shaft.
2. The soil and clay was excavated to a solid ledge, and the ground was supported by temporary timbers or concrete.
3. A bearing set of steel rails was placed on the shaft collar, and a ring of steel lining plates was bolted to the bearers with heavy steel hangers. Additional steel lining plates were then bolted in place down to the ledge.
4. Rock was drilled and blasted in such a manner that suitable fragmentation was obtained to permit the free running of the muck through the churn-drill hole upon being shoveled into the hole.
5. The shaft was lined by bolting the steel plates in place as the excavation deepened. The lining was kept as near the bottom of the excavation as possible.
6. The muck that accumulated in the mine at the bottom of the churn-drill hole was loaded mechanically and unloaded in abandoned rooms.
7. The voids behind the steel lining were filled with concrete or grout as required by the character of the ground and water conditions.

SHAFT-SINKING DETAILS

A tripod was erected over the shaft, and hoisting was done in a 5-cubic-foot bucket attached to a cable.

Shaft Collar

In sinking the air shaft, the overburden was excavated by hand showing to a convenient depth for throwing the material out of the hole. An attempt was made to drop the remainder of the overburden through the churn-drill hole, which resulted in clogging the hole.

In sinking the escape shaft, the overburden was excavated to solid shale, the opening was lined with concrete. The concrete walls have a minimum thickness of 1 foot, with a footing provided by cutting a hitch in the solid shale. The cross-sectional inside dimensions of the collar

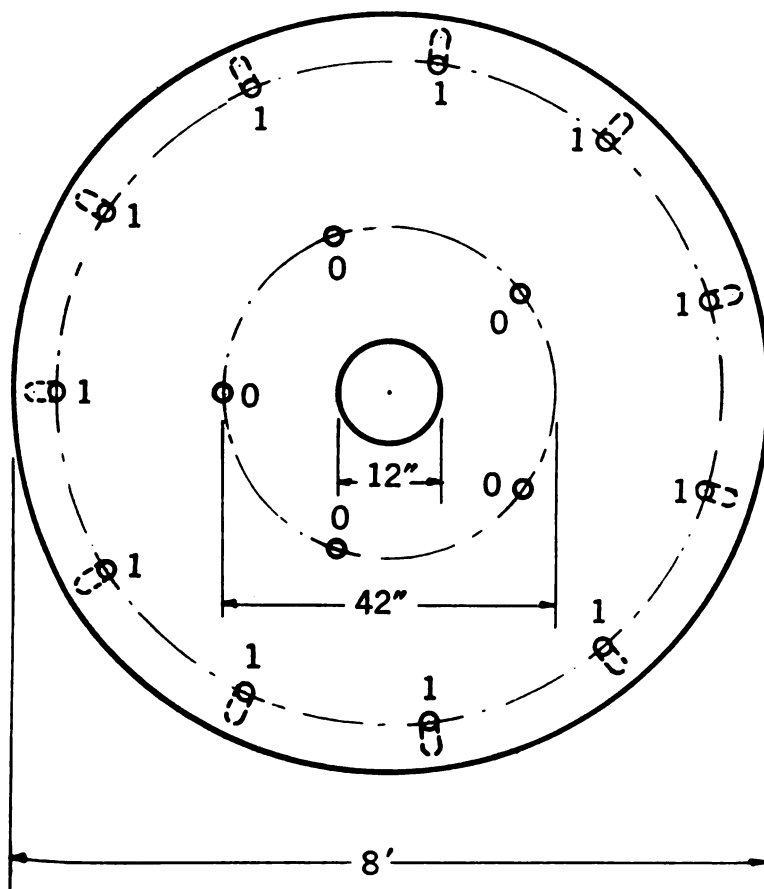


**Figure 1.—Typical drill round for
8-foot-diameter shaft.**

are 9 feet 2 inches by 9 feet 2 inches, which allowed a minimum clearance of 6 inches between the concrete walls and the steel lining. The space between the concrete walls and the steel lining was filled with concrete upon completion of the sinking operations.

The bearing set from which the steel lining was hung consisted of two 60-pound steel rails placed across the top of the concrete collar and two cross rails welded between the longer ones.

Drilling and Blasting

The rock was drilled in 2-foot rounds with a Thor jackhammer operated by compressed air supplied by a small portable air compressor.

The typical round was drilled with the holes located in two circles as shown in figure 1. The inner circle of 5 holes was 15 inches from the churn-drill hole, whereas the outer circle of 11 holes was started as close to the lining as drilling permitted and was bottomed within the neat line of the excavation.

Forty-percent dynamite was used. The entire round was fired electrically at the same time by using instantaneous electric detonators in the outer circle of holes.

Two 10-foot lengths of 40-pound rails suspended on a cable were hung in the churn-drill hole so that part of the rails extended out of the hole when a round was shot. The rails allowed only the finely broken rock to pass and prevented plugging of the drill hole by the blast; after the blast, the hole could be opened easily by snaking the cable.

Mucking

The muck was removed from the shaft by shoveling it into the churn-drill hole.

A No. 7 BU Joy loader was used for loading mine cars at the bottom of the churn-drill hole. The muck was loaded once a day, which required virtually one shift each 24 hours for a crew of 1 loading-machine operator and 2 car men.

Shaft Lining

A ring of liner plates was placed in the shaft as soon as the muck was removed after blasting.

Armco steel liner plates manufactured by the American Rolling Mill Co. of Middletown, Ohio, were used in these shafts. The plates are structural units of corrugated metal with corrugation 7 inches wide and 1-3/4 inches deep. The corrugations extend the full length of the plate, which is flanged along each side to a depth of 1-3/4 inches. The full standard plate has a covering length of 50-1/4 inches on the neutral axis, allowing for the 3-inch end lap. The width of the plate is 18 inches. Fractional plates are available.

Each section of the plate is curved to conform to specifications for the individual job. Plates are rolled for various diameters from 48 to 160 inches. It requires six full plates to make a full-circle lining having a 96-inch diameter on the neutral axis, the cross-sectional dimension of the vertical shafts at the Ditney Hill mine.

The steel-plate linings are supplied in standard gages from No. 3 to No. 14, depending on the load the lining must support. Plates used in the Ditney Hill shafts are No. 10 gage.

One end of the plate is offset to allow for the lap of the end joint. The offset depth is equal to the thickness of the metal. The overlap of the plates is 3 inches. Five half-inch bolts are staggered at the lap end of the plate, the bolt heads being welded in place.

Plates with bolts at both ends and plates provided with holes only at both ends are supplied for inside erection. The erection of a full circle set of plates in a shaft is started with a plate having bolts at both ends. The last plate to complete the ring has bolt holes at both ends and can be fitted easily over the bolts in the adjoining plates.

Four holes for 1/2-inch bolts are provided in each flange of the full plate. The flanges of two adjacent rings are bolted together to form horizontal joints at 18-inch intervals. The strength of the bolts determines the weight of liner plates that can be supported from one bearing set.

The end joints of the plates are staggered on adjacent rings, as shown in figure 2.

The steel liner plates used in the shafts at the Ditney Hill mine are made of galvanized Armco ingot iron provided with a special asbestos-bituminous coating on both sides. The plates are processed by pressing a layer of asbestos felt into the molten zinc coating as the flat plates emerge from the galvanizing rolls. The porous mass of fibers on the plate is then saturated thoroughly with a bituminous material, after which the plates are corrugated, formed, and coated with bitumen.

TABLE 1. - Properties and weights, American Rolling Mill Co. construction plate linings^{1/}

Gage	Thickness, inches	Area, sq. in.	Moment of inertia		Section modulus	
			Per inch	Per section	Per inch	Per section
14...	0.0781	1.823	0.03847	0.6925	0.0363	0.6533
12...	.1093	2.550	.0534	.9613	.0498	.8967
10...	.141	3.281	.0692	1.245	.0636	1.1443
8...	.172	4.014	.0839	1.510	.0763	1.374
7...	.188	4.388	.0919	1.655	.0833	1.499
5...	.219	5.110	.1071	1.928	.0958	1.7245
3...	.250	5.835	.1225	2.205	.1076	1.9376

^{1/} Data taken from bulletin of American Rolling Mill Co.

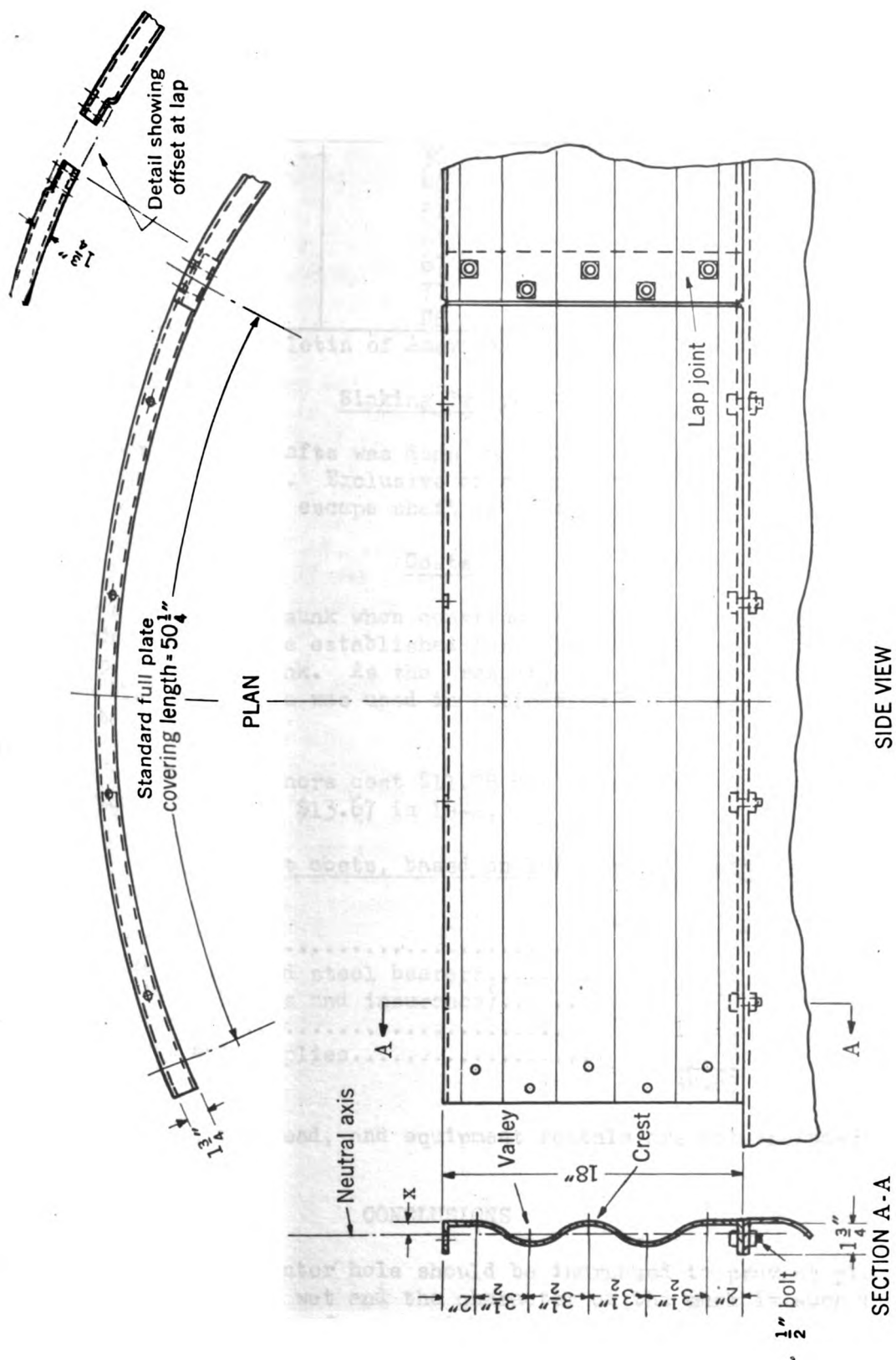


Figure 2.—Steel liner plate.

TABLE 1. - Properties and weights, American Rolling Mill Co.
construction plate linings¹ (Cont'd.)

Gage	Radius of gyration	X	Approximate standard plate weights, including bolts, pounds		
			Full size	3/4 size	1/2 size
14...	0.615	0.763	30	23	16
12...	.614	.787	40	31	22
10...	.614	.803	51	39	27
8...	.614	.823	61	47	33
7...	.614	.834	67	51	36
5...	.614	.851	77	59	41
3...	.614	.862	88	68	47

¹/ Data taken from bulletin of American Rolling Mill Co.

Sinking Progress

The work in the shafts was done on a three-shifts-a-day basis with three men on each shift. Exclusive of the collar work, the air shaft was sunk in 10 days and the escape shaft in 15 days.

Costs

The air shaft was sunk when construction wages were in force. The higher mining-wage scale established for all employees was in effect when the escape shaft was sunk. As the present hourly rate for a similar crew averages \$1, this figure was used in estimating the labor cost given in the summary below.

The steel-plate liners cost \$11.25 per linear foot of shaft delivered at the mine in 1940 and \$13.67 in 1942.

Escape-shaft costs, based on 147 feet of shaft

	<u>Cost per linear foot</u>
Churn-drill hole.....	\$2.25
Concrete collar and steel bearers.....	4.50
Direct labor (wages and insurance).....	10.58
Liner plates.....	13.67
Explosives and supplies.....	3.67
	<u>34.67</u>

Supervision, overhead, and equipment rentals are not included in this table.

CONCLUSIONS

The size of the center hole should be increased to prevent plugging by muck if the shaft is wet and the character of the muck is such that it has a tendency to ball or form a sticky mass.

It may be economical to increase the size of the center hole if the ground is blocky and it is difficult to obtain proper fragmentation to insure free running of the muck through the churn-drill hole.

A circular shaft has numerous advantages from a structural standpoint as well as being ideal for ventilation. The circular opening, particularly with flat-lying formations, requires minimum support for the shaft walls, and the circular steel lining furnishes the strongest resistance to lateral pressures for a given weight of metal.

ADAPTATION OF METHOD TO MEET STATED CONDITIONS

Deeper Shafts

The depth of 147 feet attained in the escape shaft is nearly the practical limit for hanging a continuous section of steel lining from one support. A concrete bearer at the required intervals is recommended in deeper shafts depending on the weight of lining used.

This recommendation is contingent upon the ability of the rock walls to give proper support for a concrete ring. In constructing such a ring, a footing should be provided by cutting a hitch in the rock and pouring concrete between the steel lining and rock walls to a height of three or four liner-plate rings.

Unstable Horizons in the Rock Formations

In sinking a shaft, unstable horizons that were not disclosed by drilling and other mine openings may be encountered. In sections of the shaft requiring special support, it is suggested that a concrete lining be installed by pouring concrete behind the steel lining, the same way that the concrete ring previously mentioned was placed. Half sections of the liner plates should be available to permit replacing full plates and providing openings for pouring the concrete.

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